

# A LARGE SCALE HYBRID THERMAL PRINT HEAD

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A high speed direct drive thermal print head, which prints across a 216 mm wide paper using 1728 heating resistor dots (8 dots/mm) has been developed.

It can print 30 cm long paper in only a few seconds. The head consists of heating dots, over three hundred LSI chips, a couple of dozen capacitors and multilayer thin and thick film circuit substrate.

The substrate is 240 × 70 mm by 1.0 mm thick conductor line width/space is 50 μ/50 μ. Hybridizing heating elements, drivers and shift registers on one substrate has made it possible to transmit signals serially into the head.

Therefore, the I/O pin number has become far smaller than the number of dots, which has eliminated intermittent I/O pin disconnection.

## 1. INTRODUCTION

The thermal print head heats small areas on the thermal sensitive paper in the form of multiple dots arranged to obtain a required pattern. The conventional head merely consists of heating elements array. A little more advanced thermal head consists of heating dots and conductor matrix combined with diode isolation.

In these cases, drivers or shift registers to drive the elements are mounted on the printed circuit board, where they are electrically connected to a thermal print head, usually with a flat cable.

Intermittent disconnections in the multiple conductor flatcable contacts often occur. The developed thermal print head is a one-piece thermal print hybrid module, consisting of heating dots, shift register LSIs, driver IC chips and multilayer circuit. Thus, as mentioned in the abstract, intermittent disconnection has been eliminated.

In order to manufacture the one-piece module, a hybrid process of thick film screen printing, photolithographic thick film firable evaporated thin film non firable evaporated thin film, sputtered cermet or oxide film, plating, chip die mounting, wire bonding and repairable hermetic sealing has been developed.

Developed one-piece thermal print head size is 1/20 the conventional unit size.

## 2. DESIGN

The 99.5% alumina substrate is 240 × 70 × 10 t (mm). 1728 heating resistor dots are formed on the glaze mesa. The dot is 100 μ × 200 μ and the dot to dot pitch is 125 μ, thus the space is 25 μ.

All dots are electrically connected to the hammer driver, whose inputs are connected to 32 bit latchable bilateral shift registers throughout the substrate.

There are over 300 semiconductor chips and almost 30 noise killing capacitors. The shift register shift clock is 1 MHz. Each 512 bit shift register has shift register signal input, thus shifting time is 512 μ sec. At the end of shifting, all data can be latched and

the output from the register is the latched data, independent of shift register data and movement.

All the 1728 dots can be driven simultaneously, if necessary, Heating dots driving time is 0.6 to 3.0 msec and maximum duty is 50%. Thus, the minimum printing time required for an A4 sheet of paper is 2.8 seconds.

The peak driving power of each dot is 0.5 to 1.4 W, being inversely proportional to driving time.

A block diagram of the head is shown in Figure 1.

### 3. CONFIGURATION

A drawing of the developed module is shown in Figure 2.

1728 dots are lined in parallel with a common electrode to which all heating dots are connected.

Conductor lines, coming from the other side of the dots, go under the dielectric layer. Underneath the heating dots, a glaze mesa is formed to get m-second order heating insulation.

A cross-sectional view is shown in Figure 3.

LSI chips are mounted and wire bonded to the substrate and hermetically sealed by a metal cap with solder.

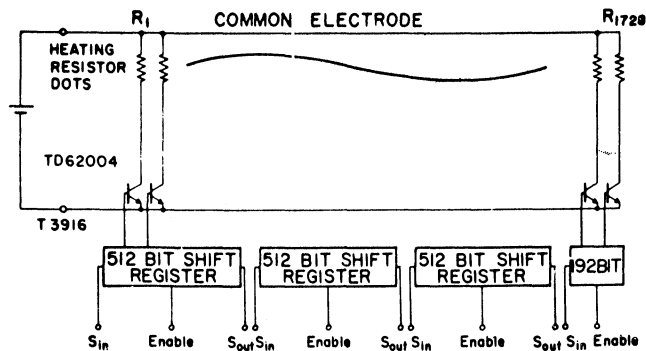


FIGURE 1 1728 dot direct drive thermal print head equivalent circuit.

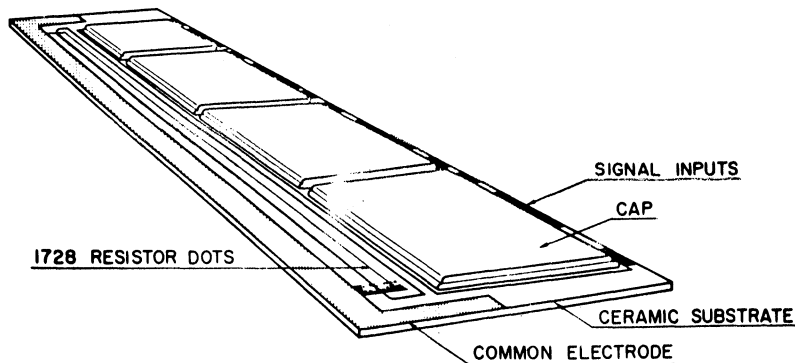


FIGURE 2 A4-8dot direct drive module.

Inert gas is charged into the cap. As the cap is soldered, it can be easily removed, and new chips can be mounted to replace a damaged one.

In order to protect fine lines near resistors, a cover glaze is sputtered over the resistors and lines.

This material is hard enough to endure traversing 100 km over the print paper. Due to the hermetic sealing and this sputtered glaze protection, all circuits are completely protected from moisture.

#### 4. MANUFACTURING PROCESS

This module can be called not only a hybrid of many elements, but also a hybrid manufacturing process. This process is shown in Table 1.

Primarily, gold or silver paste is printed on the ceramic substrate with screen printing technology.

1st metal is formed by metal evaporation and photo etching process. A photograph is shown in Figure 4. The detail of this material and manufacturing process was previously reported by the author.<sup>1</sup> It is firable and repairable with gold conductor paste.

Thus, even first metal dimensions are as small as 50  $\mu$  space and its yield is almost 100%.

1st dielectric layer is processed by thickfilm printing and photo lithographic patterning, whose details were also reported in a previous paper.

2nd dielectric process is the same as the 1st dielectric process. The via filling process has also been previously reported.<sup>1</sup>

Sealing dielectric, seal ring, common electrode and glaze are screen printed. After the circuit process completion, the substrate will be submitted to short-open test. If a fault is found, the circuits can be repaired by thick film paste.

TABLE I  
A4-8DD manufacturing process.

Process	Material	Method	Reference
I/O Leads	Au or Ag	Thick film printing	
1st metallization	Thin film Au Alloy	Evaporation	
1st Dielectric	Glass	Thick film/dry film	
2nd Metallization	Thin film Au alloy	Evaporation	
2nd Dielectric	Glass	Thick film/dry film	
Via fill	Au	Mask Blade method	
Seal ring dielectric	Glass	Thick film printing	
Seal ring	Au	Thick film printing	
Common electrode	Au or Ag	Thick film printing	
Glaze	Glass	Thick film printing	
Resistors	Tantalum Cermet	Sputtering	
3rd Metallization	Cr-Pd-Au-Cr	Evaporation	
Passivation	Ta <sub>2</sub> O <sub>5</sub>	Sputtering	
4th Metallization	Ti-Au	Evaporation	
Copper plating	Cu	Electro plating	
Solder reflow	Sn <sup>63</sup> /Pb <sup>37</sup>	Hot plate	
Chip die mount	Epoxy	Auto dispenser	
Wire bonding	Au	Auto bonder	
Test			
Hermetic seal	Inert gas	Soldering	

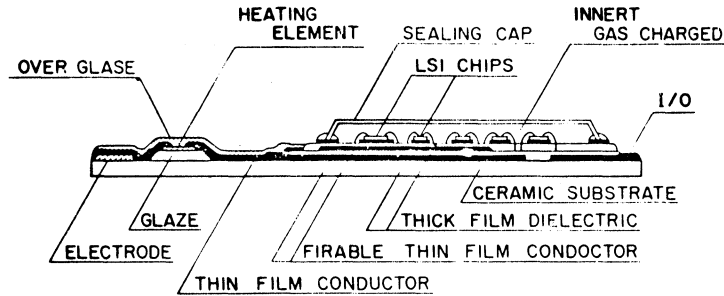


FIGURE 3 Water-proof Toshiba direct drive thermal print head cross-sectional view

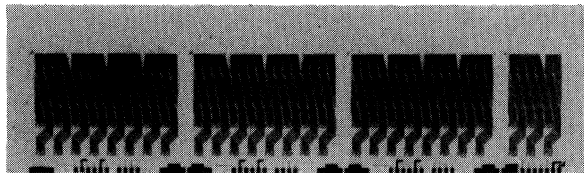


FIGURE 4 Metal forming by evaporation and photo etching process.

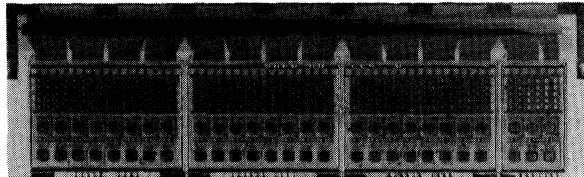


FIGURE 5 Chip mounted and wire bonded sample.

Resistor material  $\text{Ta-SiO}_2$  is sputtered and gold film is successively evaporated with adhesive metal. After the photolithographic patterning of gold conductor and resistor,  $\text{Ta}_2\text{O}_5$  is sputtered over it.

Then, gold conductor paste pattern, which is to be soldered, will be copper plated to get good solder leach resistance. Solder is reflowed over the copper pattern.

There are close to 6000 bonding wires. By multichip automatic wire bonder, bonding can be completed in less than one hour.

The chip mounted and wire bonded sample is shown in Figure 5.

After printing tests, the hybrid will be hermetically capped.

Characters printed by this head are shown in Figure 6. A prototype thermal printer model is shown in Figure 7.

A size comparison between the developed thermal print head and a conventional unit is shown in Figure 8.

This particular example is for use in railroad ticket vending machines.<sup>2,3</sup>

A conventional unit consists of Dips on PCB, flexible cable and a printing head (Figure 8, top). The developed unit is one piece (Figure 8, bottom). The interior of the new head (Figure 8, bottom) is shown in Figure 9.



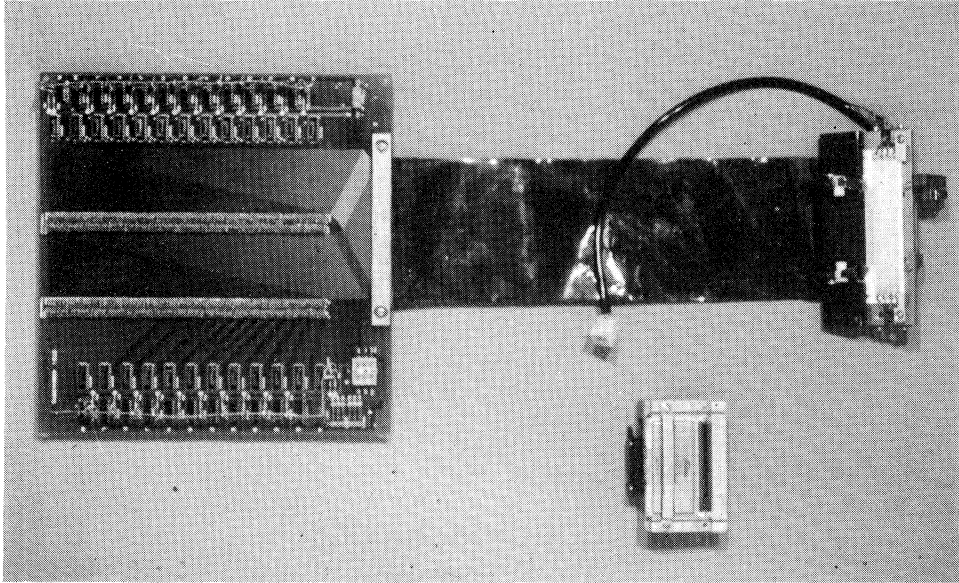


FIGURE 8 Size comparison between a conventional unit (top) and the new Thermal Print Head (bottom).

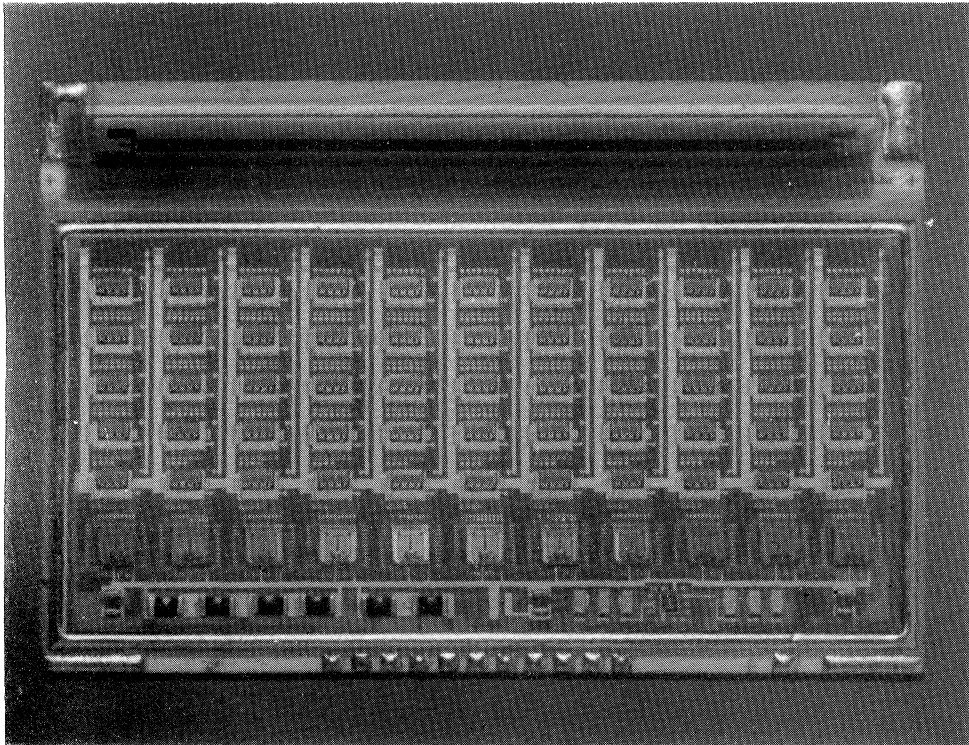


FIGURE 9 The interior of the new Thermal Print Head.

## 5. CONCLUSION

One piece hybridization of resistors, drivers and shift resistors with hybrid technology for evaporation, sputtering, firable thin film, thick film photolithographic thick film, automatic wire bonding and hermetic sealing, has made it possible to reduce thermal print head size to 1/20th the conventional unit size, to eliminate intermitted disconnection error in multiple connections and to provide easy handling during the maintenance.

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